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ABSTRACT

This unit of instruction was designed as a laboratory-oriented course, to relate the causes of motion of masses which are moving in other than a straight line. The booklet lists the relevant state-adopted texts and states the performance objectives for the unit. It provides an outline of the course content and suggests experiments, field trips, speakers or resource people, and topics for student projects, reports, and additional innovative activities. Also listed are relevant films, film loops, and transparencies available from the Dade County Audiovisual Center. Reference books, laboratory guides, and sources of discussion questions and solved problems are recommended, and a master sheet is provided relating each suggested activity to the specific performance objectives. (JR)

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U.S. DEPARTMENT OF HEALTH
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

AUTHORIZED COURSE OF INSTRUCTION FOR THE QUINMESTER PROGRAM

DYNAMICS II

5318.03

SCIENCE
(Experimental)

DADE COUNTY PUBLIC SCHOOLS

DIVISION OF INSTRUCTION • 1971

SE 014 886

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DYNAMICS II

5318.03

SCIENCE
(Experimental)

Written by Robert C. Sanderson
for the
DIVISION OF INSTRUCTION
Dade County Public Schools
Miami, Fla.
1971

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DYNAMICS II

COURSE DESCRIPTION:

A laboratory-oriented course which relates the causes of motion of masses which are moving in other than a straight line.

ENROLLMENT GUIDELINES:

1. Strongly recommended if the student plans further studies in science or technology.

2. Elective.

3. Successful completion of Kinematics, Dynamics I, and mathematics through Plane Geometry is strongly recommended as indicators of success in Dynamics II.

STATE ADOPTED TEXTS:

1. Genzer, Irwin and Youngner, Philip. Physics. Morristown, New Jersey: Silver Burdett Company, 1969.

2. Miller, Franklin, Jr., et al. Concepts in Physics. New York: Harcourt, Brace and World, Inc., 1969.

3. Rutherford, F. James, et al. The Project Physics Course Text. New York: Holt, Rinehart and Winston, Inc., 1970.

4. Williams, John E., et al. Modern Physics. New York: Holt, Rinehart and Winston, Inc., 1968.

PERFORMANCE OBJECTIVES

The student will:

1. Given certain demonstrations, identify three basic types of equilibrium.

2. Given the preceding demonstrations, specify the force relationships for stable, unstable, and neutral equilibrium.

3. Given laboratory opportunity, experience the static laws of neutral equilibrium with planar and coplanar forces.

4. Given a series of equilibrium problems, be proficient in force analysis after having completed objectives 1-3.

5. As a result of teacher demonstration and class demonstrations, realize how to use forces and equilibrium to locate center of mass.

6. Given laboratory opportunity, experience the existence of centripetal force.

7. Using his experimental data, synthesize the mass, velocity, radius equation for centripetal force.

8. Using his experimental data, with group discussion, prove the fallacy of centrifugal force on a mass in circular motion.

9. Using Newton's laws of motion, mathematically derive the equation for centripetal acceleration.

10. Given the opportunity to analyze experimental data and equations for F_c and A_c, generalize the laws for curvilinear motion.

11. Given data, be proficient in problem solving involving curvilinear motion on a horizontal plane after having completed objectives 6-10.

12. Given data, realize the role of the weight vector in circular motion in other than a horizontal plane.

13. Given a series of demonstrations, analyze the function of friction and banking in curvilinear motion.

14. After class discussion, apply the concept of centripetal force by solving a selection of problems dealing with the concept.

15. Given a teacher presentation and classroom discussion, relate circular motion to angular measurement.

16. Given selected problems in circular motion, be proficient in conversion and problem solving after having completed objectives 6-15.

17. Given reading assignments and class discussion, realize the concept of universal gravitational attraction and the scientists associated with it.

18. Using data related to the universe (earth, sun, moon, man, etc.), be proficient in solving problems relating to gravitational pull, escape velocity, and orbit after having completed objectives 6-17.

19. As a result of readings and class discussion, identify scientists and their theories of planetary motion.

20. Using self study and class discussion, derive Kepler's three laws of planetary motion.

21. Given data relating to Kepler's laws, be proficient in problem solving after having completed objectives 19-20.

22. Given the definition of simple harmonic motion, in class discussion, identify the many types.

23. Given classroom demonstration, realize the simple harmonic motion of a mass moving in a circular path.

24. As a result of class discussion, generalize the concept of frequency and period.

25. Given laboratory opportunity, relate pendulum motion to energy, centripetal force, frequency, and period.

26. From his data, synthesize basic relationships for pendulum motion.

27. Given laboratory opportunity, experience the application of Newton's laws to the motion of a mass rotating about an axis.

28. Using furnished data, relate the conservation of linear momentum to a rotating mass.

29. Using furnished data, relate the conservation of energy to a rotating mass.

30. As a result of teacher demonstration and class discussion, generalize the concept of torque, moment of inertia, power, and work.

31. Using furnished data, be proficient in problem solving involving rotational motion after having completed objectives 1-30.

32. Given selected problems, the student will be proficient in problem solving involving any type of force on any mass based on related completed objectives.

COURSE OUTLINE

I. Newton's Laws of Motion

II. Force Analysis of Three Types of Equilibrium (Stable, Unstable, Neutral).

III. Analysis of Neutral Equilibrium and The Laws of Statics.

A. Planar

B. Coplanar

IV. Determination of Center of Mass by Force Vectors

V. Laboratory Investigation of Masses Moving in Horizontal Circular Plane

A. Centripetal Force

B. Centripetal Acceleration

VI. Introduction of Angular Measurements for Circular Motion

A. Angular Velocity

B. Angular Acceleration

C. Angular Displacement

VII. Methods of Conversion Between Linear and Angular Motion

VIII. A Study of Universal Gravitational Force and Scientists' Theories

IX. A Study of Kepler's Laws

X. Simple Harmonic Motion

A. Spot on Wheel

B. Pendulum

C. Vibrator (Buzzer)

XI. The Relationships Among Period, Frequency, and Amplitude in simple harmonic motion

XII. Rotation of a Mass Around Its Axis

A. Torque

B. Moment of Inertia

C. Rotational Kinetic Energy

D. Work

E. Power

XIII. Applications of Dynamics to Simple Machines and Games

A. Lever

B. Pulley

C. Flywheel

D. Billiards

E. Bowling

XIV. Efficiency and Mechanical Advantage

XV. Summarization of Laws of Motion

A. Newton

B. Conservation of Momentum

C. Conservation of Energy

EXPERIMENTS

Dillon, Thomas J. and Smith, Malcolm K. Concepts in Physics Laboratory Manual. New York: Harcourt, Brace and World, Inc., 1969.

1. Projectile Motion (Ex. 6, p. 12)
2. Determining the Path of a Projectile (Ex. 7, p. 14)
3. Energy of a Simple Pendulum (Ex. 11, p. 18)
4. The Pendulum Revisited (Ex. 12, p. 20)
5. Centripetal Force - Method 1 (Ex. 17, p. 26)
6. Centripetal Force - Method 2 (Ex. 18, p. 27)
7. The Period of Simple Harmonic Motion (Ex. 20, p. 31)
8. The Period of a Simple Pendulum (Ex. 21, p. 33)

Genzer, Irwin and Youngner, Philip. Laboratory Investigations in Physics. Morristown, New Jersey: Silver Burdett Company, 1969.

9. Another Way of Looking at Force Vectors (Ex. 6-II, p. 35)
10. Projectiles on Target (Ex. 8-I, p. 47)
11. Circular Motion (Ex. 8-II, p. 51)

Holton, Gerald, et al. The Project Physics Course Handbook. New York: Holt, Rinehart and Winston, Inc., 1970.

12. Curves of Trajectories (Ex. 10, p. 52)
13. Prediction of Trajectories (Ex. 11, p. 55)
14. Centripetal Force (Ex. 12, p. 57)
15. Centripetal Force on a Turntable (Ex. 13, p. 58)
16. Activities (P. 50 - p. 62)

Physical Science Study Committee. Physics Laboratory Guide. Atlanta: D. C. Heath and Co., 1965.

17. Forces on A Ball in Flight (Ex. III-4, p. 41)
18. Centripetal Force (Ex. III-5, p. 44)
19. Changes in Potential Energy (Ex. III-11, p. 55)
20. Energy of a Simple Pendulum (Ex. III-12, p. 56)

Williams, John E., et al. Exercises and Laboratory Experiments in Physics. New York: Holt, Rinehart and Winston, Inc., 1968.

21. Resolution of Forces (Ex. 7, p. 17)
22. Parallel Forces (Ex. 8, p. 19)
23. Center of Gravity and Equilibrium (Ex. 9, p. 21)
24. Centripetal Force (Ex. 13, p. 28)
25. The Pendulum (Ex. 14, p. 30)
26. Efficiency of Machines (Ex. 15, p. 31)
27. Conservation of Energy (in a spring) (Ex. 16, p. 33)

PROJECTS

1. Design and construct an apparatus to demonstrate the laws of statics.

2. Design and construct a center of mass apparatus.

3. Design and construct a visual aid that will illustrate the concepts used in a centrifuge.

4. Design and construct a centripetal force gauge that will also tell linear speed.

5. Investigate the relationship between centripetal force and gravitational force in a minimum speed loop-the-loop. Plot this relationship.

6. Research the tire industry for the safest tire relative to friction and centripetal force.

7. Research the phenomena of 'planing' relative to wheel braking on wet pavement. Build a demonstration model.

8. Design and construct a 'skid' table for scale model cars.

9. Design and construct a projectile motion-free fall apparatus for classroom demonstration.

10. Design a working model of a free satellite orbiting a sphere.

11. Construct an apparatus that will help relate circular motion to straight line motion.

12. Design and build a modified Foucault pendulum.

13. Construct a working model to demonstrate gravitational attraction and its variables.

14. Diagram, on poster board, a torque wrench with explanations.

15. Design and build a simple bridge structure to meet given specifications.

16. Design a new type of door latch.

17. Design a new car jack.

18. Design and build a crane to meet given specifications.

REPORTS

1. The Universal Law of Gravitation
2. Orbit: From Electron to Space
3. Clocks: Sundials to Tuning Forks
4. Tires for Safety
5. Highways for Safety
6. Cavendish: A Man With Pull
7. Kepler: Moongazer
8. The Closest Thing to Perpetual Motion
9. As the Universe Changes, So Does Our Motion
10. Ten Simple Tools: Their Relation To Curvilinear Motion
11. New York to Miami by Projectile -- Its Implications
12. Circular Motion for Homes and Buildings
13. How Do We Bend a Laser Beam?
14. Centripetal Force at Supersonic Speeds
15. A Ten-Speed Bike: How It Works and Why Build It?

FIELD TRIPS

1. Billiard Parlor
2. Driver Education Range
3. Gymnasium
4. Athletic Field
5. Machine Shop
6. Water Ski Trip
7. Expressway Interchange
8. Amusement Park
9. Automobile Races (Oval Track)
10. Tennis Courts

SPEAKERS OR RESOURCE PEOPLE

1. Highway Engineer
2. Airline Pilot
3. Aero-Space Engineer
4. Race Car Driver
5. Architectural Engineer

FILMS AVAILABLE FROM DADE COUNTY AUDIOVISUAL CENTER

1. Centripetal Force and Satellite Orbits
   AV#1-01784, 11 minutes, BW, Coronet
2. Deflecting Forces (0305)
   AV#1-30272, 29 minutes, BW, MLA
3. Elliptic Orbits (0310)
   AV#1-10701, 18 minutes, BW, MLA
4. Frames of Reference (0307)
   AV#1-30265, 26 minutes, BW, MLA
5. Free Fall and Projectile Motion (0304)
   AV#1-30275, 30 minutes, BW, MLA
6. The Pendulum
   AV#1-30275, 12 minutes, BW, MLA
7. Periodic Motion (0306)
   AV#1-30255, 25 minutes, BW, MLA
8. Principles of Gearing: An Introduction
   AV#1-13211, 18 minutes, BW, UW
9. Simple Machines
   AV#1-01766, 11 minutes, BW, EBEC
10. Universal Gravitation (0309)
    AV#1-30205, 30 minutes, BW, MLA
11. Work, Energy and Power
    AV#1-10665, 23 minutes, BW, Almananc

FILM LOOPS

The Project Physics Course Materials. New York: Holt, Rinehart and Winston, Inc., 1970. Super 8. Color

Unit 1: Concepts of Motion

1. Analysis of a Hurdle Race: Part 1
2. Analysis of a Hurdle Race: Part 2

Unit 2: Motion in the Heavens

3. Central Forces: Iterated Blows
4. Kepler's Laws

Unit 3: The Triumph of Mechanics

5. Gravitational Potential Energy
6. Kinetic Energy
7. Conservation of Energy: Pole Vault
8. Conservation of Energy: Aircraft Takeoff

(NOTE: All Loops $24.95 each)

TRANSPARENCIES

R.C.A. "Educator-Aides". Camden, New Jersey: R.C.A. Educational Services, R.C.A. Service Company, 1962.

1. Parallel Forces
2. Equilibrium
3. Variation of Gravity with Distance
4. The Path of a Projectile
5. Centrifugal and Centripetal Motion
6. Cavendish Balance
7. Torque Vector
8. The Gyroscope
9. Simple Harmonic Motion Displacement Graph
10. Displacement, Velocity and Acceleration in Simple Harmonic Motion
11. Simple Machines (3)

SUGGESTED DISCUSSION QUESTIONS

1. What is meant by equilibrium?
2. Does force have a part in equilibrium?
3. Can we relate center of mass to anything else?
4. Upon what does centrifugal force act?
5. Can a body travel in a circle without a force acting on it?
6. Where is the centripetal force on a revolving phonograph record?
7. What is a flywheel?
8. What forces are on you at this instant?
9. If the earth stopped spinning, would we weigh the same?
10. When does gravity act as a centripetal force?
11. Why do masses attract each other?
12. Why do some masses repel each other?
13. How do we know how much to bank a road?
14. What does centripetal force have to do with driving safety?
15. If you were at the center, how could you determine the speed of an object travelling in a circular path?
16. Why did it take so long to reach Kepler's Laws?

17. How many examples of everyday simple harmonic motion can you dream up?

18. What do a wheel and a pendulum have in common?

19. How many ways can a wheel be moving?

20. How does a car engine get started?

21. What is the difference between moment and torque?

22. What is a torque wrench?

23. What would happen if there were no curvilinear motion?

RELATED SOLVED PROBLEMS

1. Castka, Joseph F. and Lefler, Ralph W. Physics Problems. New York: Holt, Rinehart and Winston, Inc., 1961. (pp. 166-184), (pp. 209-234)

2. Dillon, Thomas J. and Smith, Malcolm K. Concepts in Physics, Teachers' Manual and Answer Key. New York: Harcourt, Brace, Jovanovich. 1970. (pp. 84-91), (pp. 96-101).

3. Physical Science Study Committee. P. S. S. C. Physics Teachers' Resource Book and Guide. Boston: D. C. Heath and Co., 1965. Part III.

4. Schaum, Daniel. Theory and Problems of College Physics, Sixth Edition. New York: Schaum Publishing Co., 1961, Reprint 1966. (pp. 11-14), (pp. 17-23), (pp. 31-32), (pp. 58-61), (pp. 68-69), (pp. 72-73).

5. Williams, John E., et al. Modern Physics Teachers' Edition. New York: Holt, Rinehart and Winston, Inc., 1968. (T30), (T34), (T36), (T38), (T41-T42), (T44-T45), (T46).

6. Williams, Stanley, et al. Physics, Student Study Guide With Programmed Problems. (To Accompany Physics, Parts I and II, by Halliday and Resnick), New York: John Wiley and Sons, Inc., 1970. (pp. 8-14), (pp. 21-27), (pp. 38-44), pp. 54-67), (pp. 73-78), (pp. 92-99), (pp.106-110), (pp. 118-124), (pp. 140-145), (pp. 149-153), (pp. 161-169), (pp. 179-189).

ADDITIONAL INNOVATIVE ACTIVITIES

1. Use a circular slot car track so that the car, at a known speed, sweeps out angles measured at the center. Compute angular relationships.

2. Set up a "hot wheels" loop-the-loop track with the bridge jump. Students study conservation of energy, centripetal force, kinematics.

3. Build a cavendish apparatus with students as masses.

4. Use a turntable for simple harmonic motion and centripetal force examples.

5. Suspend a massive pendulum for investigations.

6. Shoot and drop a B.B. for projectile motion examples.

7. Build a small-scale swing for studies of gravity, relative to centripetal force.

8. Analyze amusement park equipment relative to dynamics.

9. Analyze the two types of brakes used on passenger cars.

10. Study the complete motion of a Yo-Yo.

11. Analyze a baseball "curve".

12. Discuss boat propellers and automobile engines relative to torque.

13. Try to list the immediate forces acting on a student.

14. Design an energy transfer toy which uses as many types of motion as possible.

REFERENCES

1. Bennett, Clarence E. Physics Without Mathematics. New York: Barnes and Noble, 1949.

2. Carman, Robert A. A Programmed Introduction to Vectors. New York: John Wylie and Sons, 1963.

3. Castka, Joseph F., and Leftler, Ralph W. Physics Problems. New York: Holt, Rinehart and Winston, Inc., 1961.

4. Fuchs, Walter R. Physics for the Modern Mind. New York: The Macmillan Company, 1967.

5. Genzer, Irwin and Youngner, Philip. Physics. Morristown, New Jersey: Silver Burdett Company, 1969.

6. Halliday, David and Resnick, Robert. Physics, Parts I and II. New York: John Wylie and Sons, Inc., 1967.

7. Holton, Gerald and Roller, Duane H. D. Foundations of Modern Physical Science. Reading, Mass: Addison-Wesley Publishing Co., Inc., 1958.

8. I.P.S. Introductory Physical Science. Inglewood Cliffs, New Jersey: Prentice, Hall, Inc., 1967.

9. Lehrman, Robert L., and Swartz, Clifford. Foundations of Physics. New York: Holt, Rinehart, and Winston, Inc., 1965.

10. Marantz, Samuel A. Physics. New York: Benziger Brothers, 1969.

11. Miller, Franklin, Jr. College Physics. Atlanta: Harcourt, Brace, and World, Inc., 1967.

12. Miller, Franklin, Jr., et al. Concepts in Physics. Atlanta: Harcourt, Brace and World, 1969.

13. Physical Science Study Committee. Physics. Atlanta: D. C. Heath and Company, 1965.

14. Rutherford, F. James, et al. The Project Physics Course Text. New York: Holt, Rinehart and Winston, Inc., 1970.

15. Schaum, Daniel. Theory and Problems of College Physics. New York: McGraw-Hill Book Co., 1961, Reprint 1967.

16. Weisbruch, Fred T., et al. Patterns and Processes of Science. Boston: D. C. Heath and Company, 1967.

17. White, Harvey E., et al. Physics, An Experimental Science. Princeton: D. VanNostrand Co., Inc., 1968.

18. Williams, John E., et al. Modern Physics. New York: Holt, Rinehart and Winston, Inc., 1968.

LABORATORY GUIDES

19. Dillon, Smith. Concepts in Physics Laboratory Manual. New York: Harcourt, Brace and World, Inc., 1969.

20. Genzer, Irwin and Youngner, Philip. Laboratory Investigations in Physics. Morristown, New Jersey: Silver Burdett Company, 1969.

21. Holton, Gerald, et al. The Project Physics Course Handbook. New York: Holt, Rinehart and Winston, Inc., 1970.

22. Physical Science Study Committee. Physics Laboratory Guide. Atlanta: D. C. Heath and Company, 1965.

23. Williams, John E., et al. Exercises and Laboratory Experiments in Physics. New York: Holt, Rinehart and Winston, Inc., 1968.

MASTER SHEET - DYNAMICS II

Objectives	Texts	Experiments	Projects	Reports	Field Trips	Transparencies	Films	Film Loops	Discussion Questions	Related Problems	Innovative Activities	References
1 2 3	1 Ch. 6 3 Ch. 3 4 Ch. 3	9,21,22, 23	1,15,16 18	-	7	1, 2	11		1, 2	1-6	13	All
4												
5	1 Ch. 6 2 Ch. 6 3 Ch. 3 4 Ch. 3	21, 22 23	2, 15		1				3	1-6	13	All
6 7 8 9	1 Ch. 8 Ch. 12 Ch. 25 2 Ch. 7 3 Ch. 4 Ch. 8 Ch. 9 4 Ch. 5	1,2,5,6 9,10,11, 12,13,14, 15,16,17, 18,24	3,4,5 6,7,12 13,14		6,8,9	5	1,2,4	3	4,5,6 7,9,10, 13,14 23	1-6	2,4,7,8 10, 13	All
10												
11												
12 13	1 Ch. 6 2 Ch. 7 3 Ch. 4 4 Ch. 5	9,11,14, 18	8,9,11	4, 5	7, 9					1-6	13	All
14												
15	4 Ch. 5								15	4, 6	1, 13	All
16												
17 18	1 Ch. 12 Ch. 25 2 Ch. 7 3 Ch. 8 Ch. 4 Ch. 10 4 Ch. 5	13	10, 13	1,2,6, 9, 11	2,3,10	3,4,6	5, 10	1, 2 5, 10	8,9,10 11, 12 13	1-6	3,6,7,13	All
19 20	2 Ch. 7 Ch. 4 Ch. 5 3 Ch. 7 Ch. 24 4 Ch. 2 Ch. 1			7			3	4	16	1-6		All
21												
22 23 24 25 26	2 Ch. 8, 9 3 Ch. 4 4 Ch. 5	3,4,7, 8,19,20, 25,27	12	3	5	9, 10	6, 7		17, 18, 19	1-6	4,5,13	All
27 28 29 30	2 Ch. 19 3 Ch. 3 4 Ch. 5	26, 21	14, 17	10, 15 8	1,3,5 10	7,8,11	8, 9, 11		7, 20 21, 22	4, 6	5,9,10 11,12 13	All
31												
32												